simultaneously to an electric vehicle, a utility grid, and a work place. Similarly, the electric vehicle being charged may also be transferring energy to a user's home and another electric vehicle. Thus, all possibilities and combinations of energy transfer are considered to be within the scope of this disclosure.

Battery Pack Safety Hazard Mitigation

[0114] In batteries with high energy density, a safety hazard may occur due to damage inflicted on, or due to a fault, such as a short circuit, inside one or more of the battery's cells. Damage to a cell may result in overheating or emission of smoke and/or flame from the cell. The corresponding high temperature may cause cells in the neighborhood of the damaged cell to overheat and emit smoke and/or flame, and this condition may propagate to all other cells in the battery pack. In large battery packs, such as for electric vehicles, the safety hazard may be great because of the size of the fire that may result.

[0115] A battery pack includes one cell or a plurality of cells, a detection system that monitors each cell, and a mitigation system. The mitigation system includes a pressurized container of fluid, a delivery system, and one or more vent(s). The fluid may be capable of suppressing fire. In some embodiments, the delivery system includes a distribution manifold, a control valve and a channel corresponding to each cell for delivery of the pressurized fluid from the manifold to the cell such that the fluid floods the interior of the cell when the detection system detects a condition that is considered likely to result in a safety hazard. The channel may pass through the cell case or may direct the fluid at the exterior of the case in a manner that allows the fluid to pierce the cell case. The fluid floods the cell with sufficient power to force active material from the cell and out of the pack through a vent, thereby reducing the safety hazard. In some embodiments, the container may be pressurized at the time of delivery by energizing a gas generator, and no valve may be needed.

[0116] Variations include a battery pack comprised of series-connected groups of cells, which may include groups of parallel-connected cells, a detection system that monitors groups of cells and a delivery system with channels, each of which serves a group of cells, multiple valves, gas generators, and/or channels per cell, or group of cells.

Embodiments for Vehicle Charge

[0117] In some embodiments of the charging device, the charging device includes batteries for providing energy to the vehicle to charge the battery. The charging device includes a very low impedance battery. The charging device, which may be referred to as a "battery charger", in some embodiments, is in the form of a device or pod. The pod or charging device includes a number of battery cells. The battery charger battery is itself charged from an electric source such as connection to an electric utility grid or a generator. In some embodiments, the charger is connected to an electric utility grid and the battery charger is charged during off peak hours. In some embodiments, the charger is connected to a generator, and in some embodiments the generator is a Stirling machine.

[0118] In some embodiments, the battery in the charging device has a higher potential than the battery in the electric vehicle. The charging device contains a battery which may be directly coupled to the electric vehicle battery via a switch, or the like. The potential difference between the battery in the charging device and the battery in the electric vehicle causes the charge to flow from the charging device to the electric vehicle. The charging device may have enough information about the electric vehicle battery in order to be able to determine if the electric vehicle battery is due for a charge. In this situation there may be no need for a converter in the conduction path, although one may be used in some embodiments. The impedance of the two batteries, when connected, is low enough to provide sufficient charging power, yet high enough to avoid excessive charging power. An acceptable rate of charge is achieved by the combination of the potential difference between the battery in the charging device and the battery in the electric vehicle, and the total impedance of the two batteries. In some embodiments, a power converter may be used to transfer energy between batteries at different potentials.

[0119] In some embodiments, the charger battery cells are in parallel. To charge the vehicle battery, the charger battery's cells go from being in parallel to being in series. In some embodiments, less than all of the cells switch from parallel to series to charge the vehicle battery. Thus, in these embodiments, the number of cells used to charge the vehicle battery may be controlled and in some cases, not all of the cells are used. In these embodiments, the charger battery will put enough cells in series so that the potential of the charging device is slightly higher than the vehicle battery. However, in some embodiments, all of the cells may be used to charge the vehicle battery.

[0120] In some embodiments, the electrical connection between the vehicle battery and the charger battery is a plug. In some embodiments, the vehicle battery includes a copper bus and the charger battery plug is screwed onto the copper bus. This provides an insulated and efficient electrical connection.

[0121] Some embodiments of the method include a charger station including at least one battery charger apparatus or pod. The charger station may provide communication to a vehicle via satellite or other communication networks, etc., to indicate whether the charger station includes charged pods. In some embodiments, all of the pods may communicate with a central database indicating their charge status. The database may communicate with the vehicle to indicate which pods may be able to provide enough charge and the location of the pods, i.e., the charger station location.

[0122] A first vehicle battery may also provide a charge to a second vehicle battery. The first vehicle battery may include a controller to control the percentage of charge the first vehicle battery is giving to the second vehicle battery. The charge is given through an electrical connection. In some embodiments, this electrical connection is similar to the connection between the battery charger and the vehicle battery.

[0123] In some embodiments, either one or more batteries in the charging vehicle/charging device/battery charger may be charged by a satellite and/or the one or more vehicle battery may be charged by a satellite.

[0124] While the principles of the invention have been described herein, it is to be understood by those skilled in the art that this description is made only by way of example and not as a limitation as to the scope of the invention. Other embodiments are contemplated within the scope of the present invention in addition to the exemplary embodiments